🧠 Sliding Window Technique

The **sliding window** is originally a concept from **networking**, where it's used in protocols. A **protocol** is simply a set of rules that governs how data is transmitted between systems. The idea of the sliding window in programming is inspired by this networking principle.

In the context of **problem solving**, the sliding window is a powerful technique used to optimize solutions involving **arrays or strings**.

✅ When to Apply Sliding Window

You can apply the sliding window technique when:

- The input includes an **array or string**
- You're given an **integer** `k` (which usually represents window size)
- The output demands:
    - A **substring** or **subarray**
    - A condition based on **maximum**, **minimum**, **sum**, **count**, or **frequency**

The **sliding window technique comes in two forms**:

- A **fixed**-size window, where the window length remains constant throughout the traversal.
- A **variable**-size window, where the window expands or contracts dynamically based on a condition.

📈 Maximum Sum of K Consecutive Elements

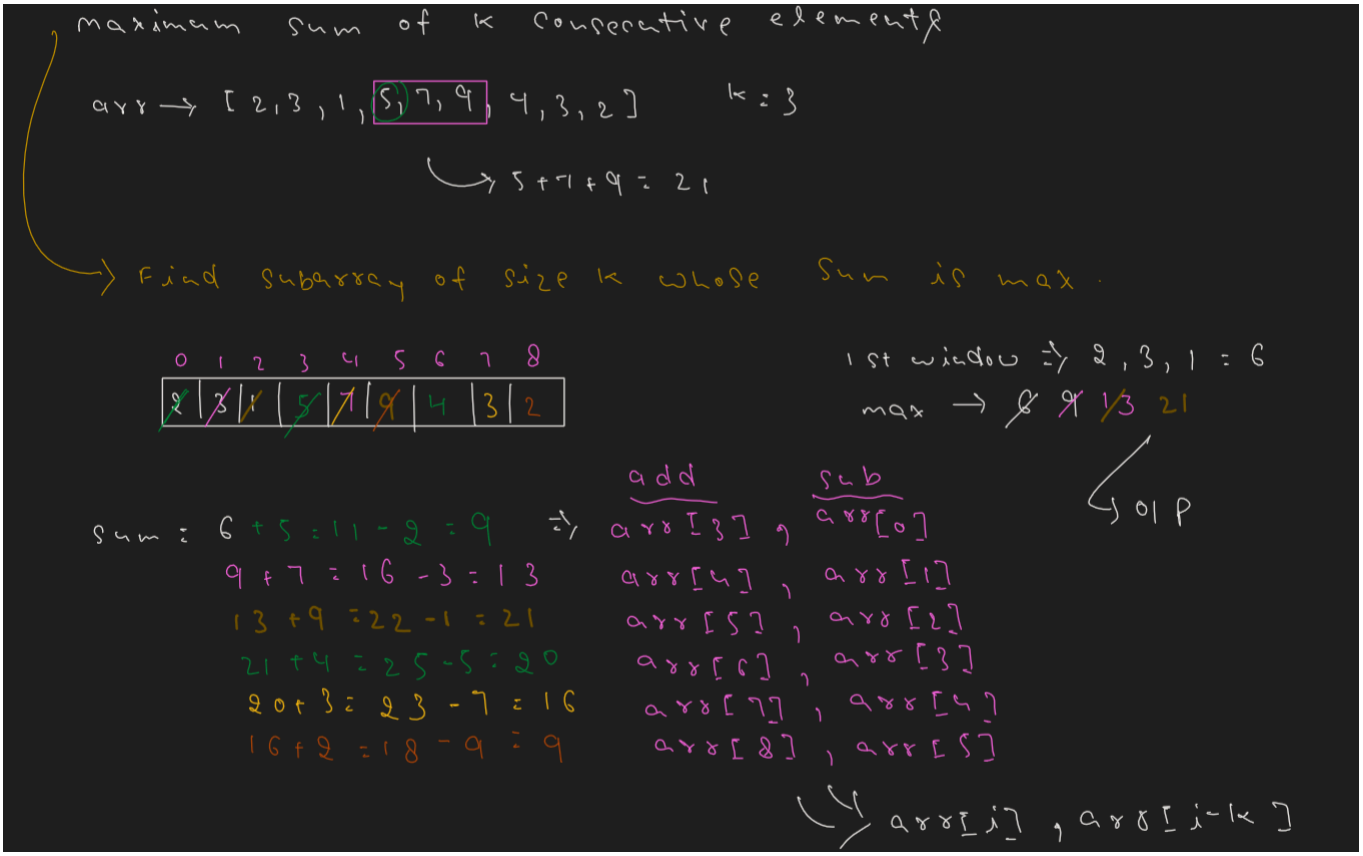
You are given an array of integers `arr[]` and an integer `k`. Your task is to find the maximum sum of any contiguous subarray of size `k`.

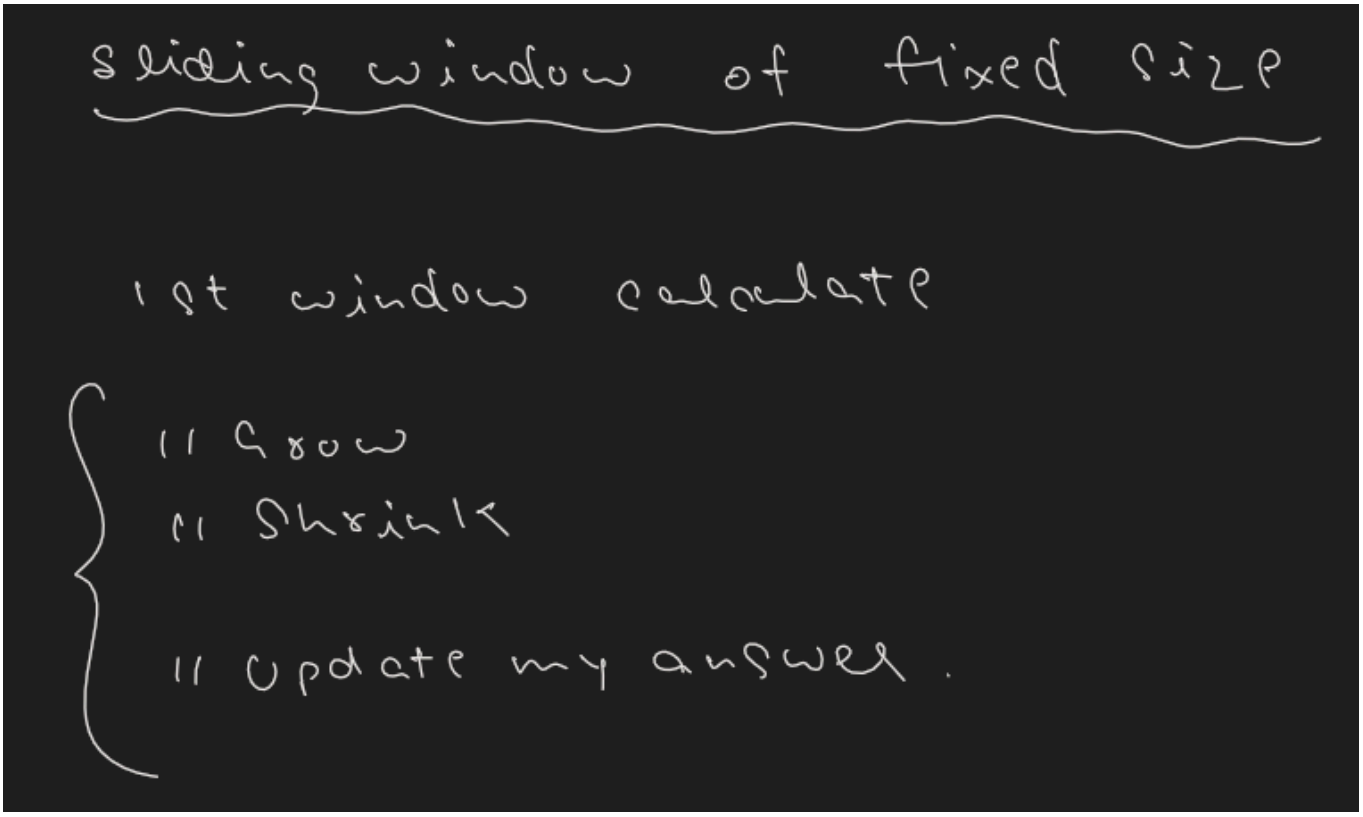
🐢 Brute Force Approach - O(n*k)

```java
public class Main {
    public static void main(String[] args) {
        int[] arr = { 2, 3, 5, 1, 5, 7, 8, 9, 1 };
        int k = 3;
        System.out.println(maximumSumBruteForce(arr, k)); // Output: 24
    }

    public static int maximumSumBruteForce(int[] arr, int k) {
        int n = arr.length;
        int maxSum = Integer.MIN_VALUE;

        // Loop through all possible subarrays of size k
        for (int i = 0; i <= n - k; i++) {
            int currentSum = 0;

            // Calculate sum of subarray starting at i
            for (int j = i; j < i + k; j++) {
                currentSum += arr[j];
            }

            // Update maximum sum
            maxSum = Math.max(maxSum, currentSum);
        }
```

```
        return maxSum;
    }
}
```

Sliding Window approach - O(n)

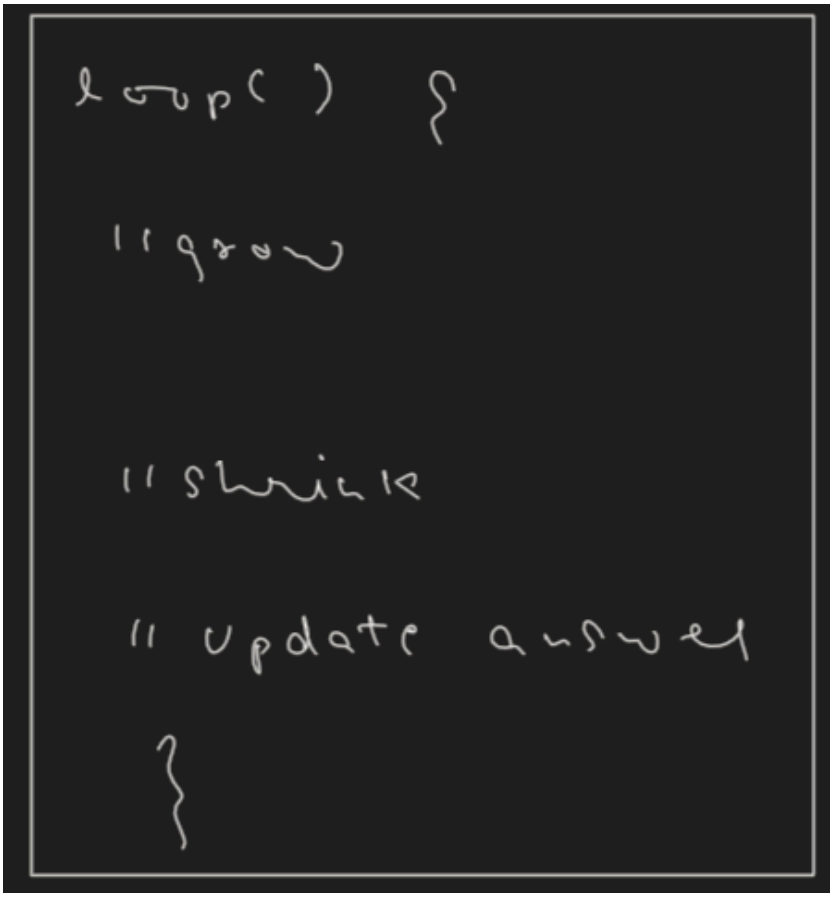


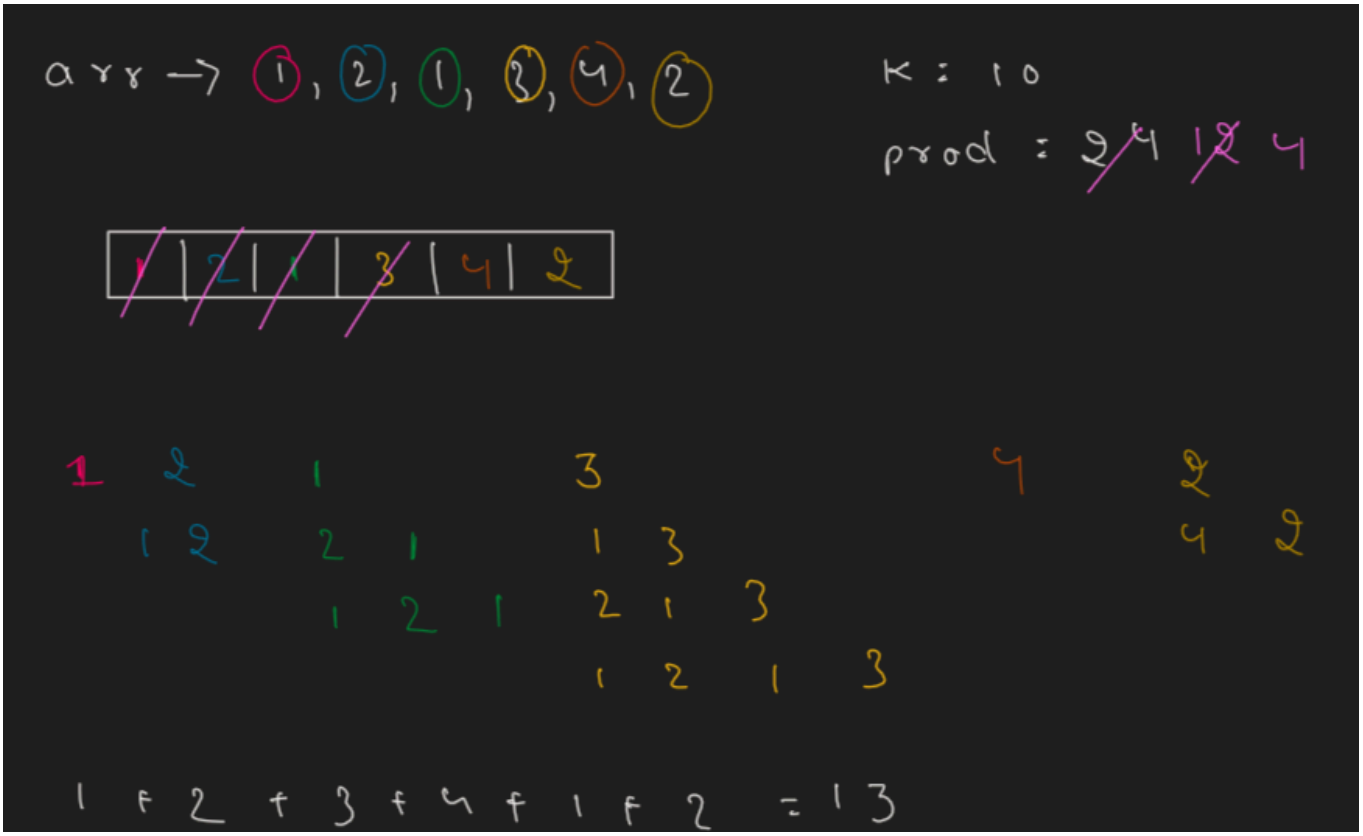


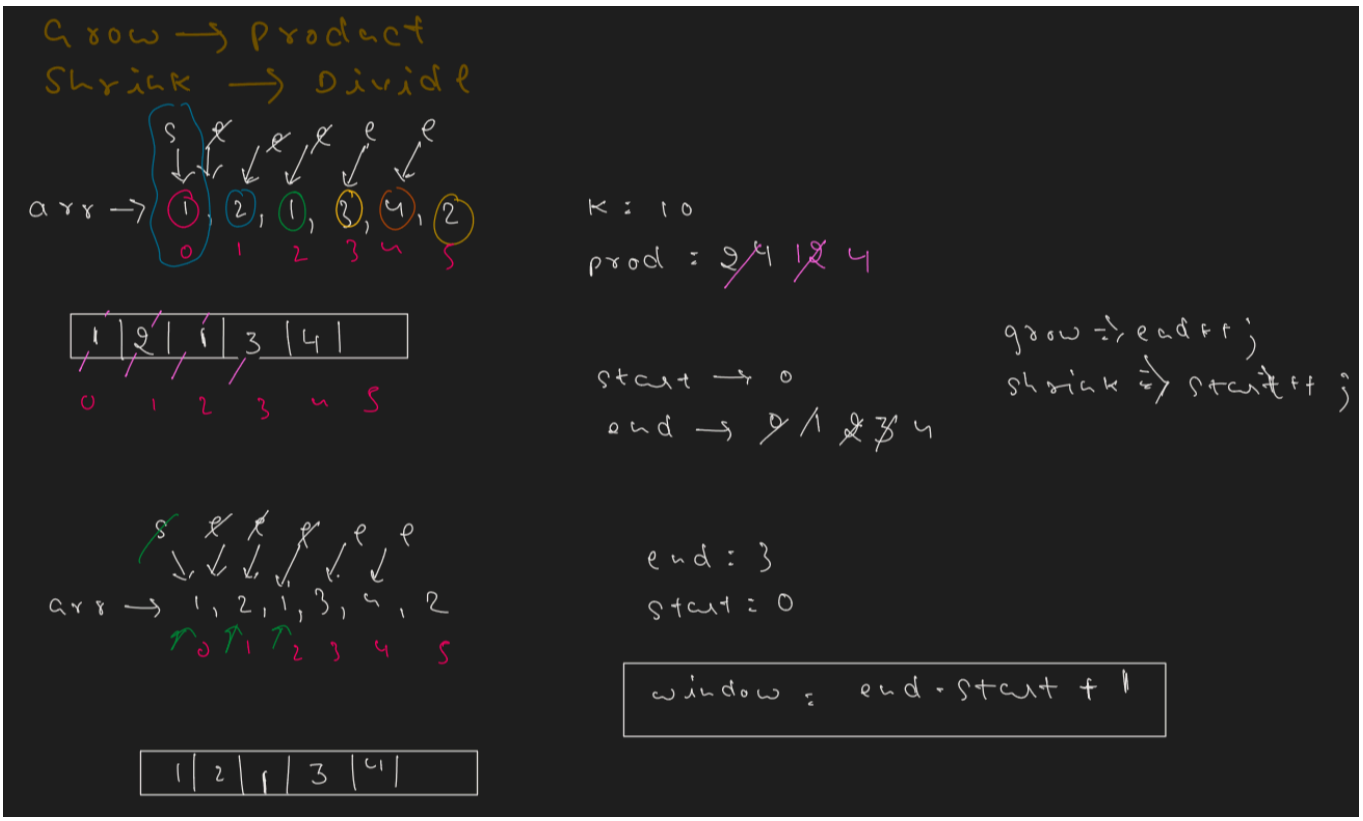
```java
public class Main {
	public static void main(String[] args) {
		int[] arr = { 2, 3, 5, 1, 5, 7, 8, 9, 1 };
		int k = 3;
		System.out.println(maxiumSum(arr, k));
	}

	public static int maxiumSum(int[] arr, int k) {
		int ans = 0;
		int sum = 0;

		// 1st window calculation
		for (int i = 0; i < k; i++) {
			sum += arr[i];
		}
		ans = sum;

		for (int i = k; i < arr.length; i++) {
			sum += arr[i]; // Grow
			sum -= arr[i - k]; // Shrink
			ans = Math.max(ans, sum);
		}
		return ans;
	}
}
```

🎯 Subarray Product Less Than K

https://leetcode.com/problems/subarray-product-less-than-k/





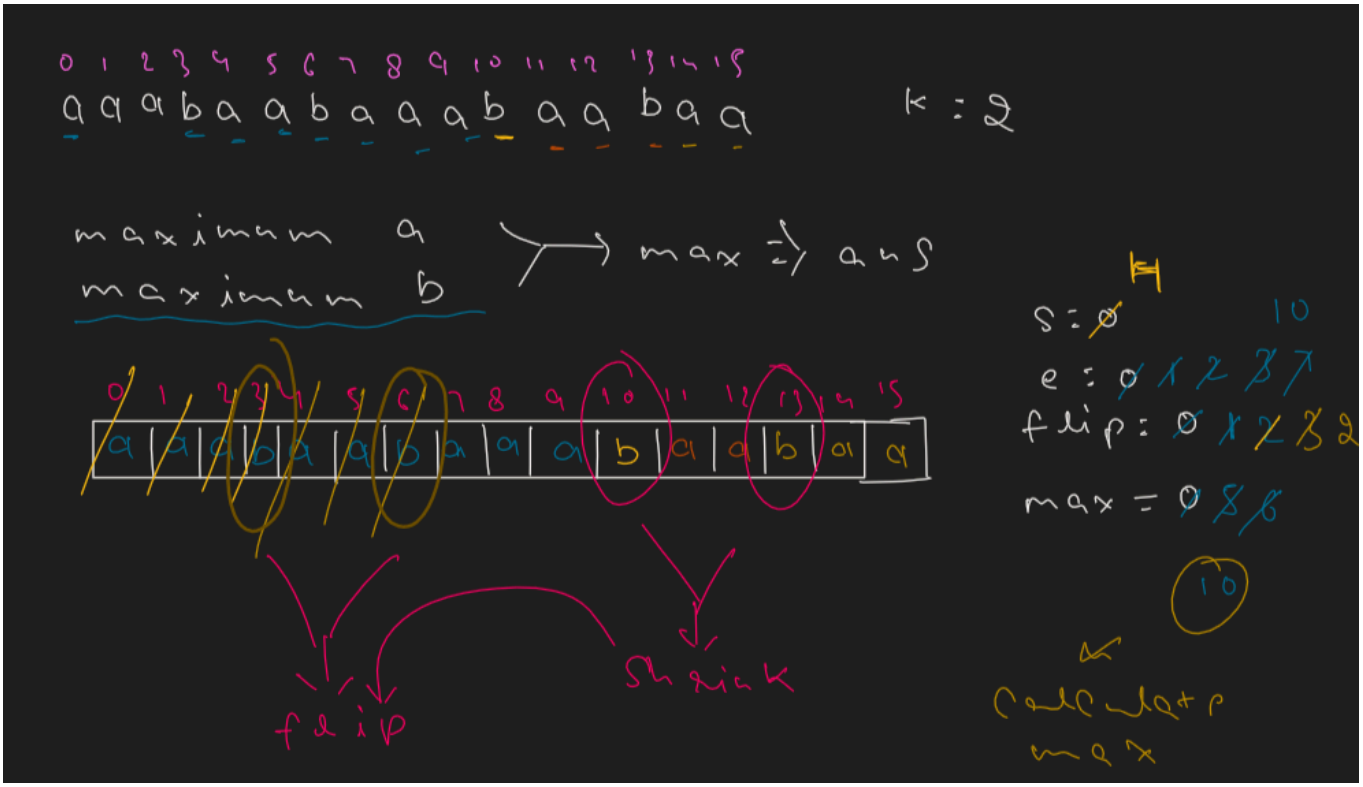


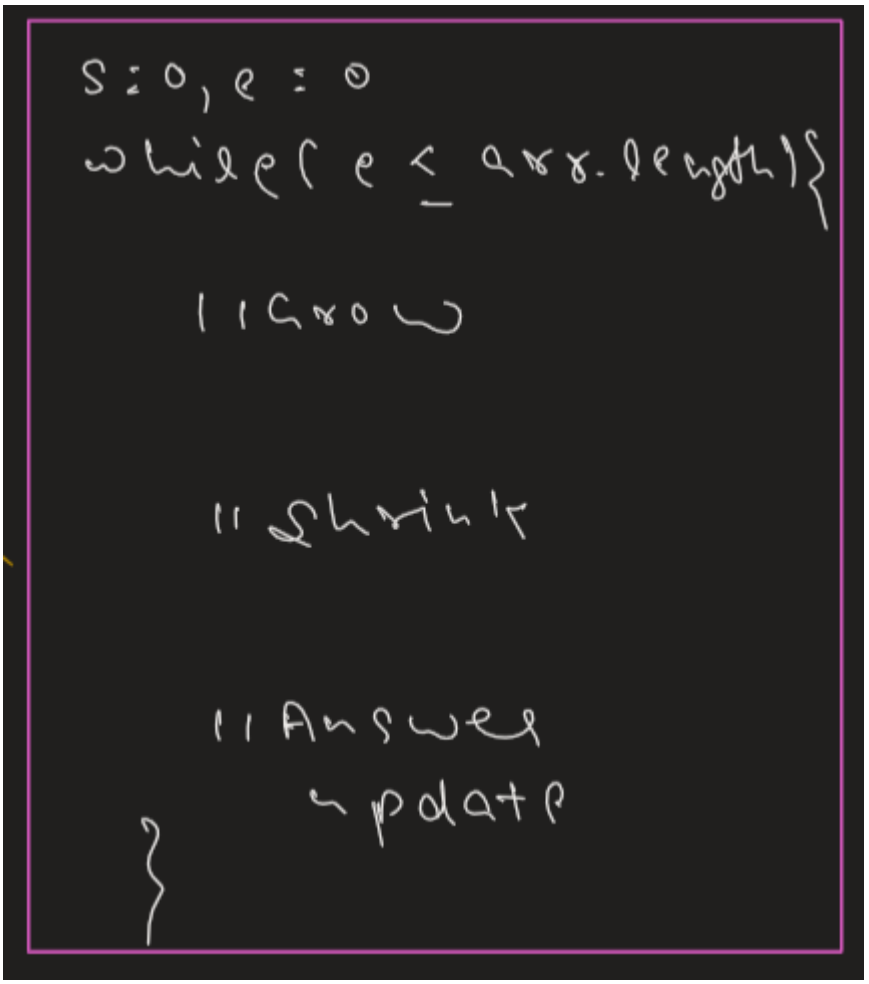

```java
public class Main {

	public static void main(String[] args) {
		int[] arr = { 1, 2, 1, 3, 4, 2 };
		int k = 10;
		System.out.println(Product_Less_Than_K(arr, k));
	}

	public static int Product_Less_Than_K(int[] arr, int k) {
		int ans = 0;
		int end = 0, start = 0, prod = 1;
```

```
            while (end < arr.length) {
                  // Grow
                  prod = prod * arr[end];

                  // Shrink
                  while (prod >= k) {
                        prod /= arr[start];
                        start++;
                  }

                  // calculate ans
                  ans += (end-start+1);

                  end++;
            }
            return ans;
      }
}
```

```
class Solution {
    public int numSubarrayProductLessThanK(int[] nums, int k) {

        if (k <= 1) return 0;

        int ans = 0;
        int end = 0, start = 0, prod = 1;
        while (end < nums.length) {
            // Grow
            prod = prod * nums[end];

            // Shrink
            while (prod >= k && start<=end) {
                prod /= nums[start];
                start++;
            }

            // calculate ans
            ans += (end-start+1);

            end++;
        }
        return ans;
    }
}
```

🎯 Kartik Bhaiya And Strings

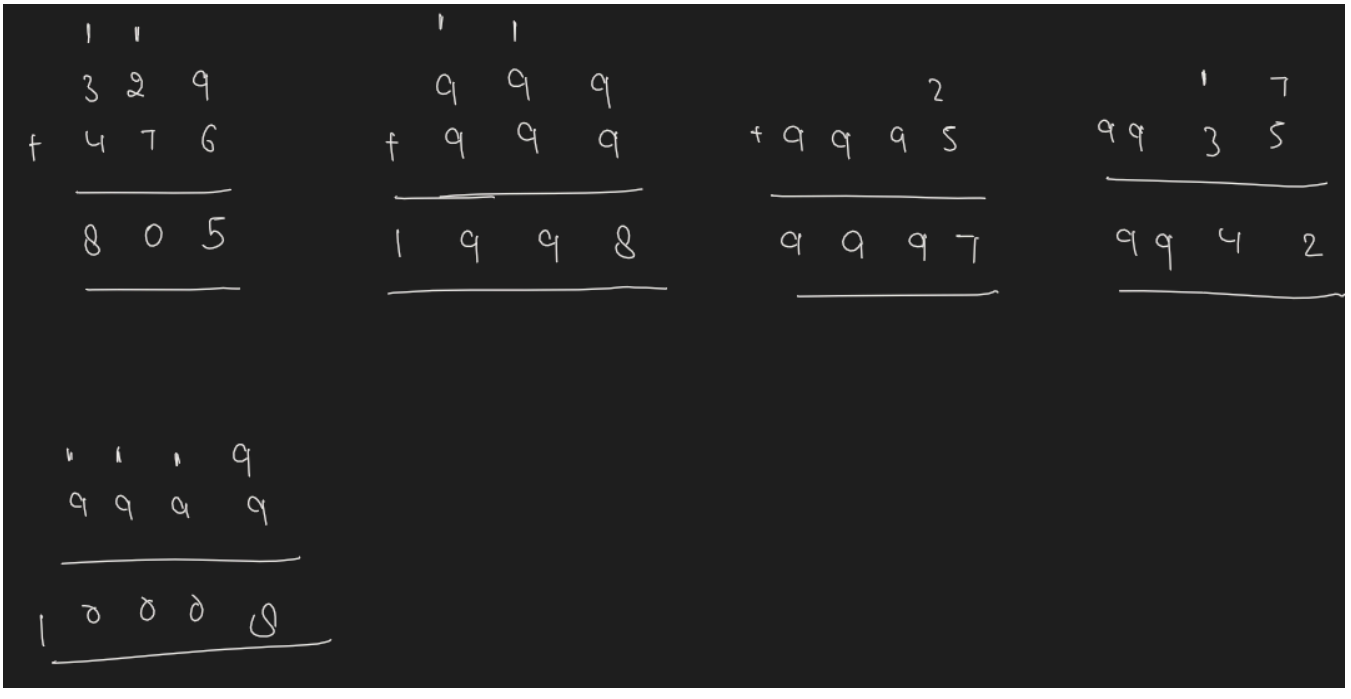





```java
import java.util.*;

public class Main {
	public static void main(String[] args) {
```

```
        // Scanner sc = new Scanner(System.in);
        // int k = sc.nextInt();
        // String str = sc.next();

        int k = 2;
        String str = "abababbababaaaaaaabbbbbaaa";
            int max_a = max_length(str, 'b', k);
            int max_b = max_length(str, 'a', k);
            System.out.println(Math.max(max_a, max_b));
      }

      public static int max_length(String s, char ch, int k) {
            int si = 0, ei = 0, ans = 0, flip = 0;
            while (ei < s.length()) {
                  // grow
                  if (s.charAt(ei) == ch) {
                        flip++;
                  }
                  // shrink
                  while (flip > k && si <= ei) {
                        if (s.charAt(si) == ch) {
                              flip--;
                        }
                        si++;
                  }
                  // calculate ans
                  ans = Math.max(ans, ei - si + 1);
                  ei++;
            }
            return ans;
      }
}
```

🎯 Arrays-Sum Of Two Arrays



```java
import java.util.*;
public class Main {

	public static void main(String[] args) {

		Scanner sc = new Scanner(System.in);
		int n1 = sc.nextInt();
		int[] arr1 = new int[n1];
		for(int i=0; i<n1; i++){
			arr1[i] = sc.nextInt();
		}
		int n2 = sc.nextInt();
		int[] arr2 = new int[n2];
		for(int i=0; i<n2; i++){
			arr2[i] = sc.nextInt();
		}
		// int[] arr1 = { 1, 0, 2, 9 };
		// int[] arr2 = { 3, 2, 4, 5, 6, 7 };
		int[] ans = sumOfTwoArrays(arr1, arr2);
		for (int i = 0; i < ans.length; i++) {
			System.out.print(ans[i] + ", ");
		}
	  System.out.println("END");
	}

    public static int[] sumOfTwoArrays(int[] a1, int[] a2){
        ArrayList<Integer> list = new ArrayList<>();
        int i = a1.length - 1;
        int j = a2.length - 1;

        int carry = 0;
        while(i>=0 && j>=0){
            int sum = a1[i] + a2[j] + carry;
            if(sum>9){
                sum = sum%10;
                carry = 1;
            } else{
                carry = 0;
            }
            list.add(sum);
            i--;
            j--;
        }
        while(i>=0){
            int sum = a1[i] +carry;
            if(sum>9){
                sum = sum%10;
                carry = 1;
            } else{
                carry = 0;
            }
            list.add(sum);
            i--;
        }
```

```
        while(j>=0){
            int sum = a2[j] +carry;
            if(sum>9){
                sum = sum%10;
                carry = 1;
            } else{
                carry = 0;
            }
            list.add(sum);
            j--;
        }

        if(carry>0){
            list.add(carry);
        }

        int[] ans = new int[list.size()];
            int l = 0;
            for (int k = list.size() - 1; k >= 0; k--) {
                  ans[l++] = list.get(k);
            }
        return ans;

    }
}
```